Quantum doughnuts slow and freeze light at will: 'fast computing & slow glass'

March 9 2009

(PhysOrg.com) -- Research led by the University of Warwick has found a way to use doughnuts shaped by-products of quantum dots to slow and even freeze light, opening up a wide range of possibilities from reliable and effective light based computing to the possibility of "slow glass".

The key to this new research is the “exciton”. This describes the pairing of an electron that has been kicked into a higher energy state by a photon, with a hole or gap it (or another electron) leaves within the shell or orbit around the nucleus of an atom. Despite its new high energy state the electron remains paired with one of the holes or positions that has been vacated by electrons moving to a higher energy state. When an electron’s high energy state decays again it is drawn back to the hole it is linked to and a photon is once again emitted.

That cycle usually happens very quickly but if one could find a way to freeze or hold an exciton in place for any length of time one could delay the reemitting of a photon and effectively slow or even freeze light.

The researchers, led by PhD researcher Andrea Fischer and Dr. Rudolf A. Roemer from the University of Warwick’s Department of Physics, looked at the possibilities presented by some tiny rings of matter accidentally made during the manufacture quantum dots. When creating these very small quantum dots of a few 10-100nm in size physicists some times cause the material to splash when depositing it onto a surface leaving, not a useful dot, but a doughnut shaped ring of material. Though originally created by accident these “Aharonov-Bohm nano rings” are

now a source of study in their own right and in this case seemed just the right size for enclosing an exciton. However simply being this useful size does not, in itself, allow them to contain or hold an exciton for any length of time.

However remarkably the Warwick led research team have found that if a combination of magnetic and electric fields is applied to these nano-rings they can actually then simply tune the electric field to freeze an exciton in place or let it collapse and re-emit a photon.

While other researchers have used varying exotic states of matter to dramatically slow the progress of light this is the first time a technique has been devised to completely freeze and release individual photons at will.

Dr Roemer said:

“This has significant implications for the development of light based computing which would require an effective and reliable mechanism such as this to manipulate light. “

The technique could also be used to develop a “buffer” of incoming photons which could re-release them in sequence at a later date thus creating an effect not unlike the concept of “Slow Glass” first suggested by science fiction author Bob Shaw several decades ago.

More information: The research paper is entitled “Exciton storage in a nanoscale Aharonov-Bohm ring with electric field tuning" by University of Warwick PhD student Andrea M.Fischer, Dr Rudolf Roemer (University of Warwick) Vivaldo L. Campo Jr. (Universidade Federal de Sao Carlos-UFSCar, Brazil), and Mikhail E. Portnoi (University of Exeter), and has just been published in *Physical Review Letters* (PRL) Vol.102, No.9), DOI: 10.1103/PhysRevLett.102.096405,

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Provided by University of Warwick